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BULLETIN

OF THE

AMERICAN GEOGRAPHICAL SOCIETY

Vol. XLII 1910 No. 10

GLACIERS OF PRINCE WILLIAM SOUND AND THE SOUTHERN PART OF THE KENAI PENINSULA, ALASKA

I.—GLACIERS OF THE NORTHERN PART OF PRINCE WILLIAM SOUND*

BY

U. S. GRANT AND D. F. HIGGINS

Prince William Sound (Fig. 1) is the large body of water extending inland from the northernmost part of the Gulf of Alaska. Its many islands and lofty shores contain ample evidence, in their glacial valleys, their deep fiords, their hanging valleys, their cirques, their rounded mountains, and their morainal deposits of profound glacial action in geologically recent times. From mountains of 2,000 to 10,000 feet in height flow down ice streams to-day which are the attenuated remnants of a vast ice field which once covered the region almost completely.

Prince William Sound was known to the Russians as Chugach Gulf. It is not a sound according to the customary usage of that term, but is an extensive bay or gulf which includes many islands. Its coast line is indented by numerous long, narrow inlets or fiords and by other less regular embayments whose shores are commonly of great complexity. The whole district is a highly dissected mountain mass which has been glaciated and then partially drowned in the sea. The form of the surface and the relations of land to water are similar to those which exist in the well-known "inside passage" of southeastern Alaska. The coast is rugged, rocky and picturesque and in many places rises abruptly from the water's edge to heights of 1,000 to 3,000 feet. Great mountains surround Prince William Sound on its east, north, and west sides and exist also on the islands at the entrance to the sound. These mountains contain large numbers of snow fields and glaciers, and magnificent views of snow-clad peaks and ice streams may be had from steamers crossing the sound. In the bays and fiords of the northern and western portions glaciers frequently reach tide water and discharge their icebergs from giant ice cliffs.

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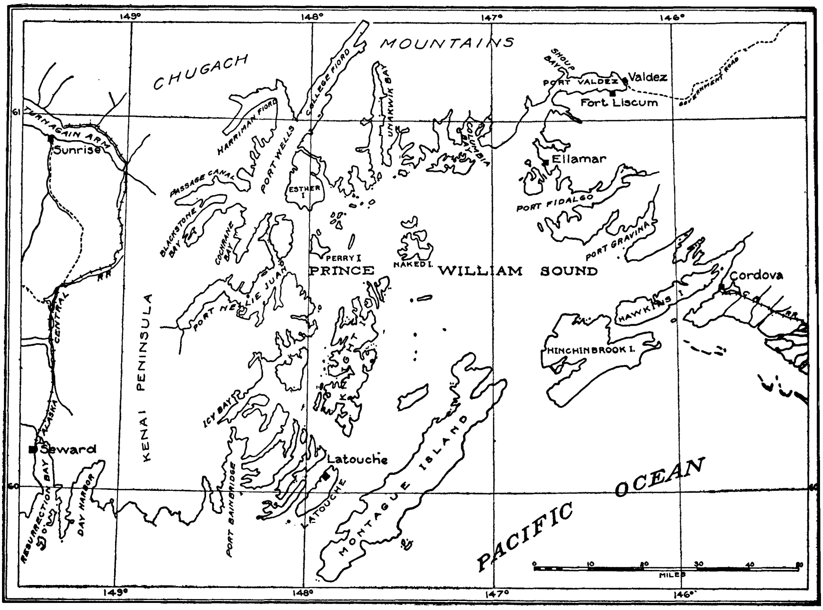

FIG. 1—Map of Prince William Sound, Alaska. Glaciers are abundant in the mountains on all sides of the sound and frequently descend to the sea in the fiords and bays of the north and west shores of the sound.

VALDEZ GLACIER

The Valdez Glacier (Figs. 2 and 3), located near the northeastern extremity of Prince William Sound, is the most noted of this district. During the spring and summer of 1898 and the early part of 1899 this glacier was used as a roadway by the horde of gold-seekers passing northward from Valdez into the Copper River and Yukon basins. The construction in 1899 of the military telegraph line and trail (followed by the development in later years of the trail into wagon road) from Valdez northward over Thompson Pass into the Copper River basin has taken away the necessity of travel over the Valdez Glacier. The front of the glacier is covered with débris, has a low slope, and is easy of ascent, although in 1898 within the first five hundred feet of rise there were three marked benches, each about 100 feet high, over which passage was difficult. The glacier itself and the method of travel over it have been interestingly described by Schrader.*

The front of the Valdez Glacier is about four miles back of the town of Valdez (Fig. 2), where it projects out of a deep valley onto a gravel plain and shows from the town in a gently curved profile (Fig. 3). There is no forest near the front of the ice, and the present thus seems to be a period of general retreat for this glacier.

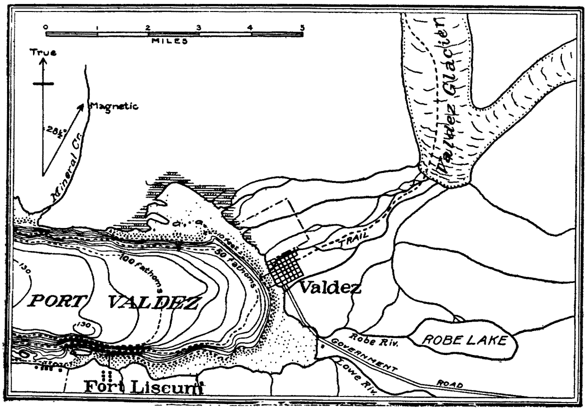

FIG. 2—Map of the head of Port Valdez and vicinity. Submarine contour lines are from data on charts of the U. S. Coast and Geodetic Survey.

There is, however, a good covering of shrubs on the valley wall near the glacial front, and close to the ice a narrow zone bare of vegetation. Thus there has been no extensive advance of the ice front beyond its present position during the twentieth century. Still oscillations of the front, as noted below, have taken place within the last few years.

We photographed the front of the Valdez Glacier in July, 1905, and the mound from which these photographs were taken was destroyed by an advance of the ice sometime before July, 1908, when we visited the glacier again and found its front about 100 feet in advance of its 1905 position. Sometime in this interval a moraine,

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* Schrader, F. C. A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: *Twentieth Ann. Rept.* U. S. Geol. Survey, Pt. 7, 1909, pp. 350–356, 365–366, 381–382.

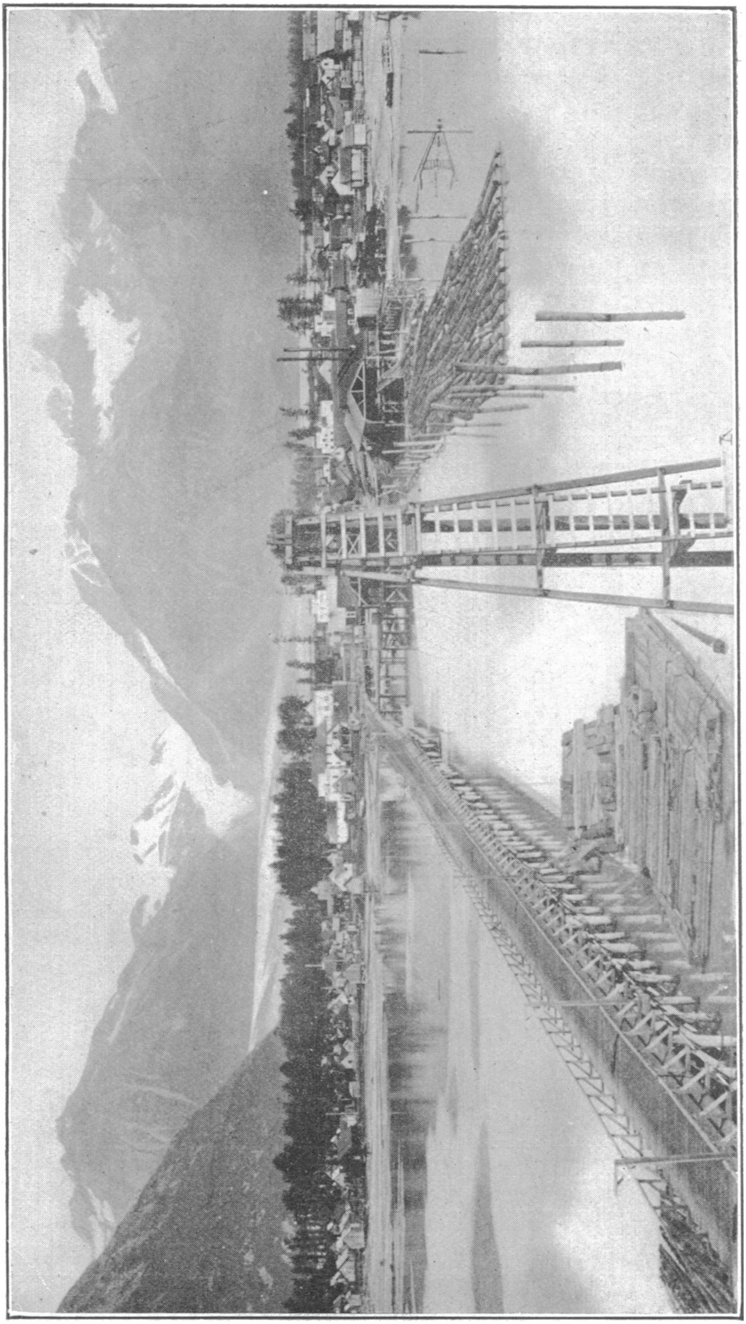

FIG. 3—Valdez and the Valdez Glacier, August, 1905. Photographed by P. S. Hunt.

10 to 30 feet in height and 25 to 125 feet wide, was deposited 250 to 300 feet in advance of the position of the front of the ice in 1905.

The plain in front of the Valdez Glacier is composed of glacial gravels deposited by the rapidly shifting and often turbulent glacial streams. Figure 4 shows these interlacing streams and the areas kept bare of vegetation by their rapid changes of courses. The white color of the streams is due to the large quantities of powdered rock, "rock flour," held in suspension. Streams from underneath moving glaciers always contain this finely divided solid matter. The streams are building the plain seaward, gradually filling in the deep rock trough of Port Valdez. The position of the outer ends of the wharves (Figs. 2 and 4) marks the change to the steeper submarine front of the advancing delta. The subærial slope of the plain is about 1 foot in 80, or an angle of about 40′; while the submarine

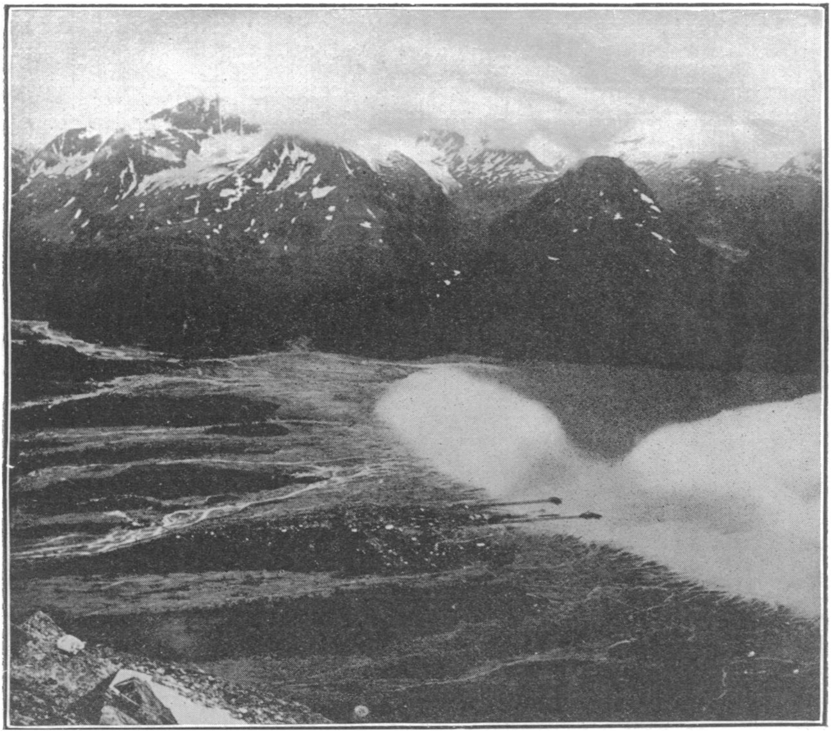

FIG. 4—Head of Port Valdez and the town of Valdez from mountain to the northwest. Photographed by G. O. Cantwell. The delta formed by Robe River and the streams from the Valdez Glacier (see Fig. 2) is gradually pushing forward into Port Valdez. Valdez is behind point shown by the two piers. Photograph taken near time of low tide.

slope averages 1 foot in 5, or 12°. The rocky submarine walls of the fiord average about 24° slope or nearly 1 foot in 3, though in one place the slope is more than one to one for 750 feet. The shape of the bottom of the fiord is shown in submarine contours in Figure 2. It is a flat-bottomed trough which was cut out to a depth of 600 to 800 feet below present sea level by the huge ice stream which once filled the whole valley to a depth of nearly 4,000 feet.

It seems quite probable that occasional slumping is taking place along the seaward edge of the delta. On February 14, 1908, a considerable earthquake visited this district and broke in several places both the Seattle-Valdez and the Valdez-Seward cables which run east and west through Port Valdez. Accompanying the earthquake there seems to have been a slumping of the delta front and a consequent burying of sections of the cables. The cause of the earthquake is not known, but it is thought to have been minor faulting, for one of the cables was broken in deep water on the flat bottom of the fiord, eleven miles from Valdez. The slumping of the delta front at this time was thus probably a result rather than a cause of the earthquake.

SHOUP GLACIER

At the northwestern angle of Port Valdez a considerable ice tributary joined the ancient trunk glacier of the main valley. With the melting and disappearance of the larger ice stream this side glacier was separated, and it is now known as the Shoup Glacier. It serves as the perennial icehouse for Valdez and Fort Liscum, the detached bergs being lifted upon barges and taken to these towns.

We mapped (Fig. 5) and photographed the glacier on June 16th, 1909. Photographs from the same point were also taken in July, both 1905 and 1908. Its front has been practically stationary during these years, but the confused records of earlier dates make it impossible to say just what was the history of advance and retreat prior to 1905. The considerable size of the shrubs close to the front of the glacier shows, however, that there has been no appreciable advance beyond the present position for probably several decades. It is reported that the rock ledges shown in Fig. 5 were not visible in 1900 and 1901. It would require an advance from the 1909 position of only about 50 feet to cover these ledges.

The submarine contours of Shoup Bay and the adjacent part of Port Valdez as shown in Fig. 5 furnish a most interesting example of a submerged hanging valley. The bottom of Shoup Bay is more than 500 feet above the bottom of Port Valdez. The gravel bar across the opening of the bay is an old terminal moraine formed when the front of the glacier was at the mouth of the bay. If the land were to emerge more than about 20 feet Shoup Bay would be a fresh water lake held in by the morainal dam. If the waters of Port Valdez were to be drawn off to the extent of 300 or 400 feet the lake would then be in an ordinary hanging valley up on the side of the trough of Port Valdez.

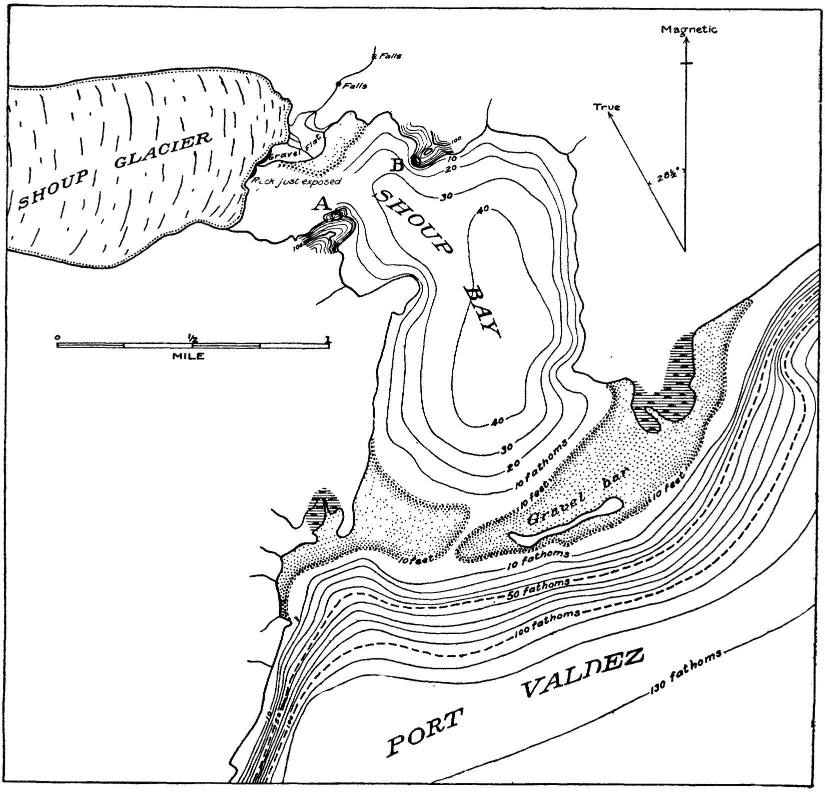

FIG. 5—Map of Shoup Glacier and vicinity, June 19, 1909. Submarine contour lines are from data on charts of the U. S. Coast and Geodetic Survey. Shoup Bay is a drowned hanging valley on the side of Port Valdez. A and B are points from which photographs of the glacier were taken in 1905, 1908 and 1909. Contour interval on land is 20 feet.

COLUMBIA GLACIER

The most interesting and the most magnificent glacier of Prince William Sound and the Kenai Peninsula is the Columbia at the head of Columbia Bay. (See Figs. 1 and 6.) This is one of the great tide-water glaciers of Alaska and of the world, and is, moreover, easily accessible to the tourist and the lover of nature.

Heading northward into the west arm of Columbia Bay we found a line of gleaming white across the head of the bay. Approaching the glacier the white line revealed itself as a tremendous wall of ice two and a quarter miles long and 400 feet high. The booming and crashing of the ice as it broke off into the sea added the last touch to make this wild and fascinating scene one never to be forgotten. Fig. 7 shows the ice wall at a distance of about a mile, with the Columbia Nunatak in the background. Even the intrepid photographer did not dare to go nearer to the jaws of this giant, for the waves caused by the falling of the ice made close ap-

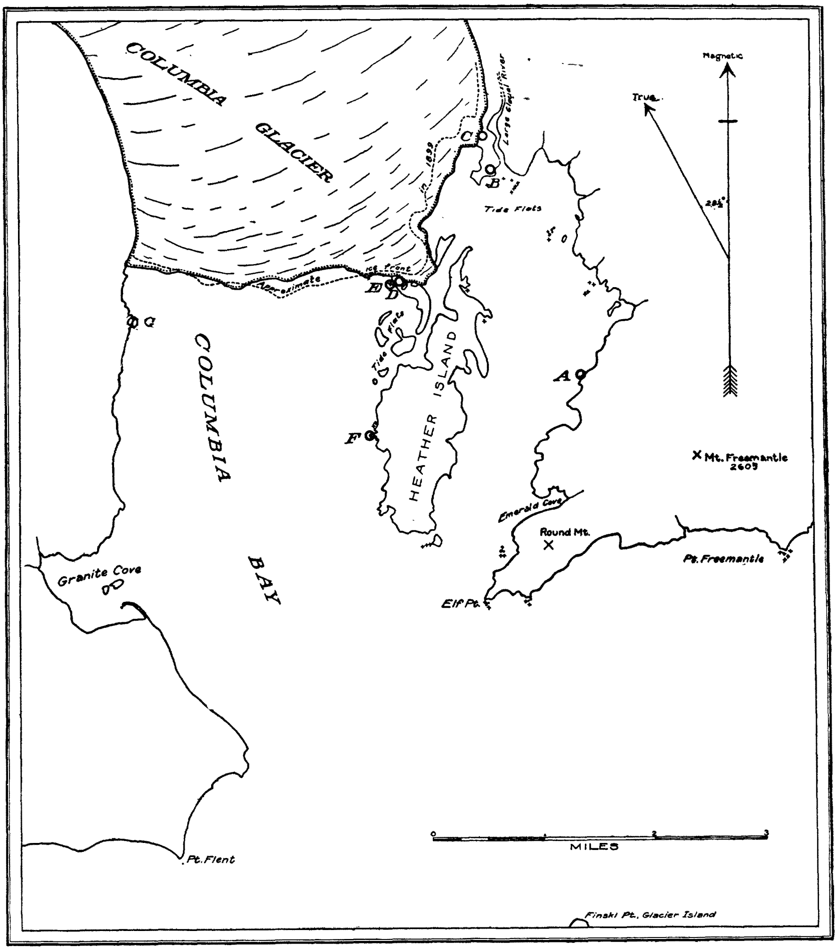

FIG. 6—Map of the front of the Columbia Glacier and vicinity, June, 1909. The points marked by circles are stations from which photographs were taken.

proach in small boats exceedingly dangerous. Small pieces of ice falling from the ice face strike the water with a sound like the snap of a rifle, while larger pieces descend with the roar of thunder, sometimes throwing the water to the height of the ice cliff. The waves generated by these ice blocks cause havoc on the adjoining shores far above the height here reached by the greatest storm waves.

In 1899 the Harriman Alaska Expedition visited this glacier and Gilbert* wrote an excellent description of it at that date. At the western edge of the glacial front Gilbert's description and photograph show a bare zone between the forest and the ice of from 200 to 300 feet in width. This locality was not examined by us in 1905 and 1908. In 1909, however, the glacier had advanced sufficiently to cover the entire bare zone and to encroach upon the forest itself. The forest is now being attacked by the ice and considerable havoc has been done by the streams along the side of the glacier and by waves caused by the fall of icebergs. We estimate that the ice at its western edge is now (1909) 500 feet in advance of its position in 1899, and that this advance has taken place, in the main, since July, 1908.

At the east edge of the glacier a swift muddy stream of considerable size enters the bay. The tongue of land between stations B and C of Fig. 6 is a sharply rolling grassy stretch. Fig. 8 shows the view from station B looking southwest. Here is a beautiful example of knob and kettle topography developed a few decades ago. The clump of trees in the left middle ground is a tiny remnant of the forest which covered all this land before the ice invasion. The largest spruce trees on the new topography are about six inches in diameter, and they are perhaps twenty years of age. But since our observations lead us to believe that vegetation gains a foothold very slowly on new glacial soil in this region of Alaska, we estimate the date of this advance at about fifty years ago. This is the earliest position of the front of which we have record since the growth of the present forest.

Morainal deposits at the north end of Heather Island, however, contain many fragments of shells of pelecypods and gasteropods which seem to be of recent species. It is improbable that these forms live in the cold milky waters near the melting ice, and so the presence of their remains in the recently deposited drift would indicate that the ice front was, in geologically recent time, considerably farther north than at present. The head of the north end of the

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* Gilbert, G. K. "Harriman Alaska Expedition," Vol. 3, 1904, pp. 71-81.

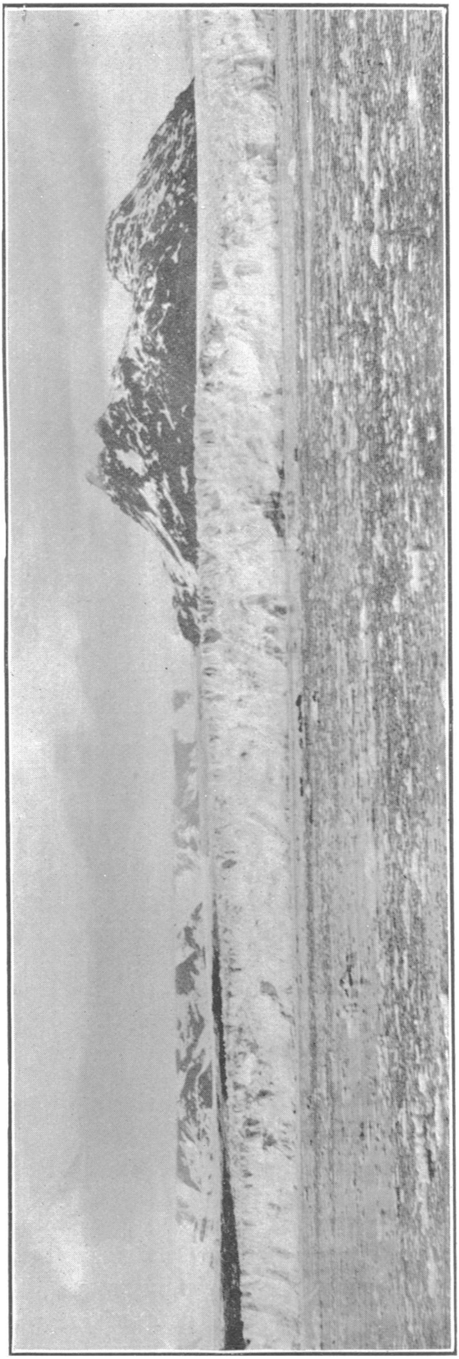

Fig. 7—Front of the Columbia Glacier and the nunatak. Photographed by P. S. Hunt.

eastern part of Columbia Bay is shallow and it is possible that a retreat of the ice front of not more than a mile might have exposed ground above tide water so shaped that the drainage from the eastern part of the glacier would have been diverted to the westward, leaving the eastern portion of Columbia Bay free of glacial waters. This condition would be favorable to the growth of molluscan life.

It was on the largest of the small islands northwest of Heather Island, however, that we found the most interesting features of the Columbia Glacier. It was here, at station D (Fig. 6), that photographs have been taken from practically the same point five times in an interval of ten years. Gilbert's photograph, taken June 26th, 1899, is here reproduced as Fig. 9, and our view, taken June 24th, 1909, is Fig. 10. The same trees and rocks can readily be recognized in each. The man standing on the small push moraine in Fig. 9 is Mr. W. A. Dickey, of Landlocked Bay, Prince William Sound. His place, in the later view, has been overrun by a few feet of ice.

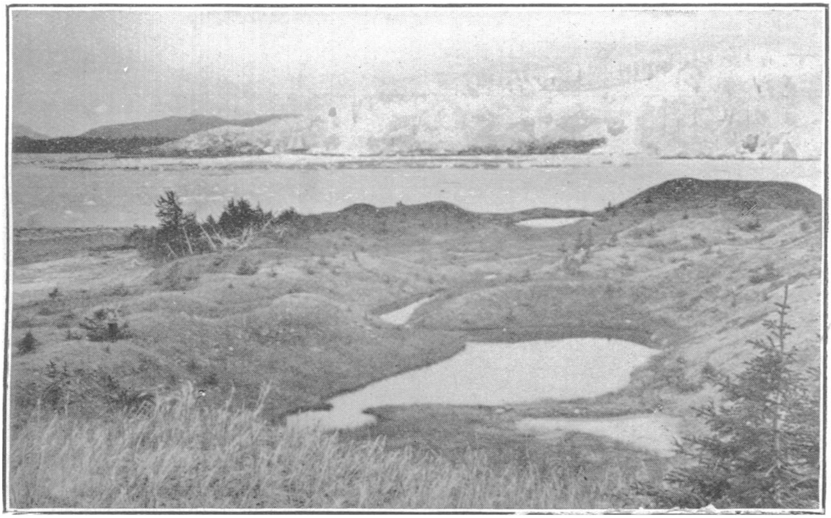

Fig. 8—Front of the Columbia Glacier from Point B (Fig. 6), June, 1909. At the left is the remnant of the forest destroyed by the advance of the glacier perhaps fifty years ago, and the morainic topography of the foreground was developed at or very shortly after the same date.

Although the ice shows in both these photographs, the front was well out of view in July, 1905, to the north (left); and in July, 1908, it was just in the edge of the picture. Briefly, the history here

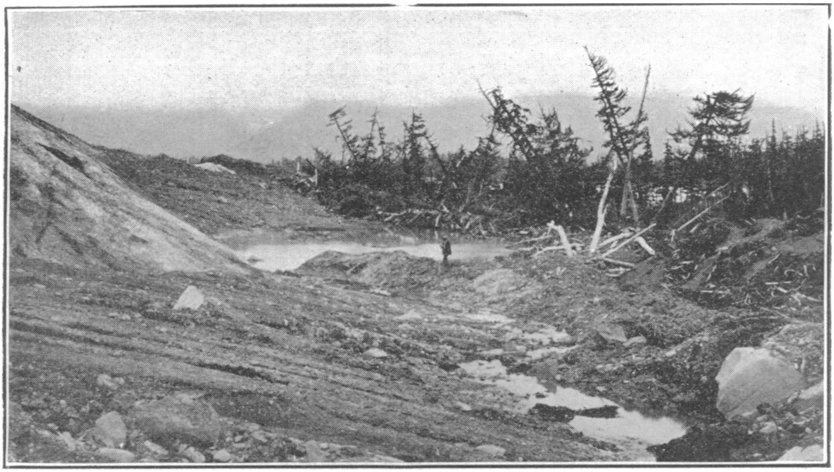

FIG. 9—Front of the Columbia Glacier and overturned forest, 1899. Photographed by G. K. Gilbert.

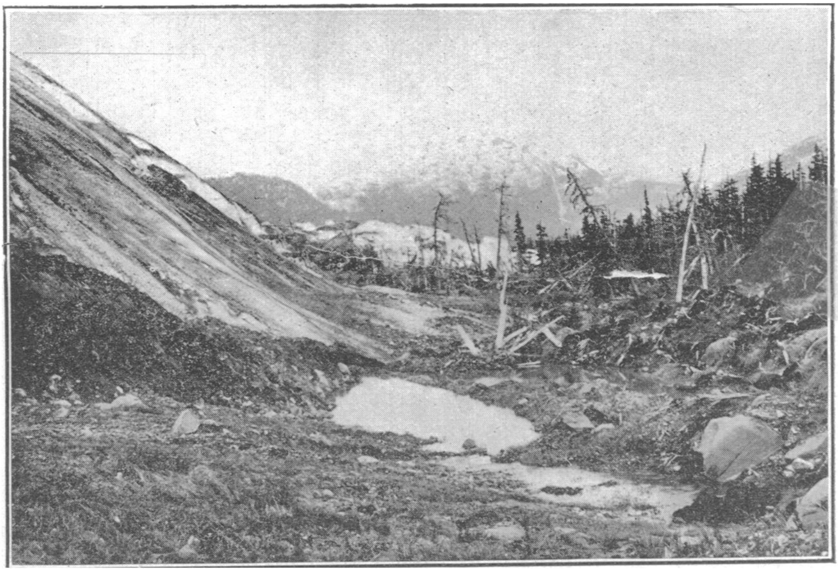

FIG. 10—Front of the Columbia Glacier and overturned forest, 1909. Photographed from the same station (D in Fig. 6) as Fig. 9. In the ten years between the dates of the two photographs much grass has grown in the foreground. In the last year the glacier has advanced, destroyed some of the trees and pushed forward others (especially the nearly erect, dead, almost branchless, tall tree on the right).

recorded is as follows: At a date estimated as 1894 the large push moraine which contains the bare dead trees and the tilted living trees was formed. We infer a still earlier advance, however, for the bare, dead trees had undoubtedly been killed before the pushing up of this moraine. Then there was a retreat an unknown distance, followed by an advance to form the small push moraine on which Mr. Dickey stood. In 1899 the distance from the small moraine to the ice was found to be 60 feet. In 1905 the ice was 220 feet north of the small moraine, but in 1908 it had advanced 100 feet. Between July 15th, 1908, and June 24th, 1909, the ice pushed forward 310 feet, and by August 23rd, 1909, as observed by Tarr and Martin, it was seventy feet (estimated) farther out and 120 feet ahead of its former (1894) maximum. Between the last two dates there was then an average rate of advance of the front of 1.17 feet per day. The actual rate of movement of the ice was considerably greater than this, for melting was at its maximum during this period.

The photographs (Figs. 9 and 10) are also of interest in showing the growth of vegetation on a freshly exposed till surface. In the first year or two no vegetation had gained a foothold. In the next six years very little grass had started to grow, though considerable fire weed (*Epilobium*), which is one of the first plants to cover the ground recently bared by ice, was much in evidence in the outer part of the bare zone. In 1909 the ground was well covered by grass, but no trees nor shrubs had put in their appearance. A number of tilted trees which were alive in 1899 had died by 1905 and still others by 1909. The dropping of twigs and bark from the dead trees, and the general decay of the trunks, progressed comparatively little between 1899 and 1909. The impression which we gathered from our visits to several such areas of forest invaded by ice and of ground recently bared is that the time since the ice invasion is very likely to be underestimated. Were it not for the evidence of dated photographs, an examination of this locality in 1909 very likely would have convinced us that the former maximum of the ice was four or five years ago rather than fifteen or more years ago.

Figs. 11 and 12 portray graphically the movement of the ice front between 1908 and 1909. The tree showing faintly at the extreme left of Fig. 11 is the lower (dead) tree in Fig. 12.

Nothing could give a more impressive illustration of the tremendous force in the moving ice than the uprooted trees and folded layers of peaty soil on this little island. No motion was visible, and an occasional snap of an overstrained piece of wood was all that gave evidence of active movement. In the advance of the ice, in 1909, into the previously disturbed forest some of the trees were pushed forward bodily without being overturned, although their inclinations were sometimes changed. One such tree had its position changed by 100 feet by June 24, 1909, and by Aug. 23 of the same year it had been moved further, but was still nearly upright.

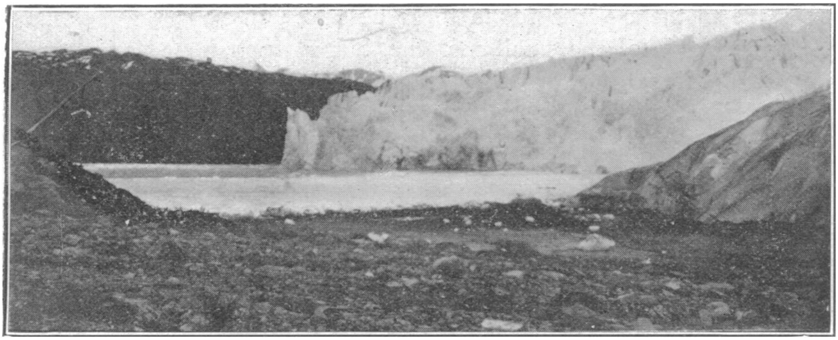

FIG. 11—Front of the Columbia Glacier, 1908.

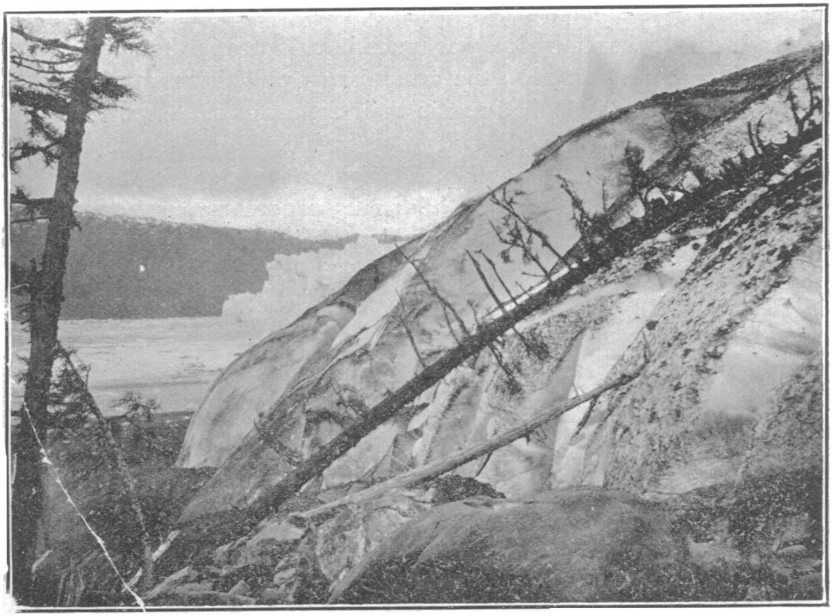

FIG. 12—Front of the Columbia Glacier, 1909. This photograph was taken from nearly the same position as Fig. 11. The lowest dead tree is the same as the one shown at the extreme left of Fig. 11.

The almost erect, dead, nearly branchless tree shown on the right in Fig. 9 has been pushed forward and can easily be recognized in Fig. 10. At the west edge of this island we found one of the most forcible visual evidences of the glacier's strength. Here the ice was literally plowing up the beach gravels into a ridge 25 feet high (Fig. 13), and such an example of titanic and silent force could not but arouse feelings of awe and of profound respect for the white giant.

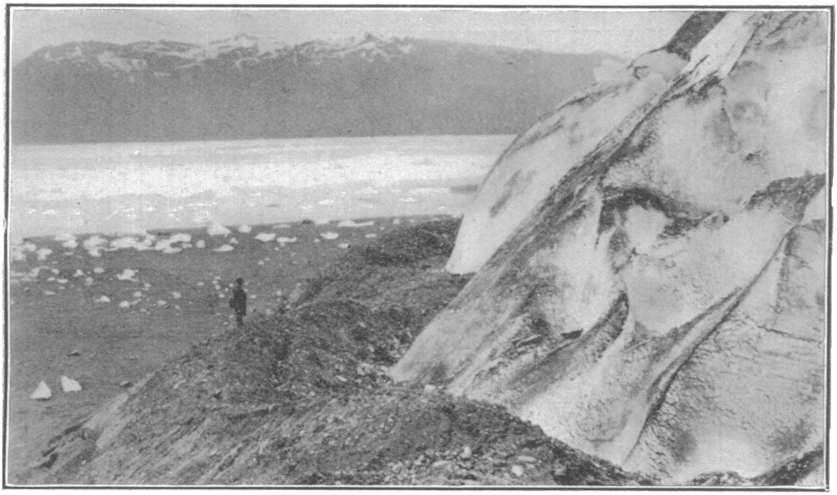

FIG. 13—Push moraine 25 feet high at front of Columbia Glacier.

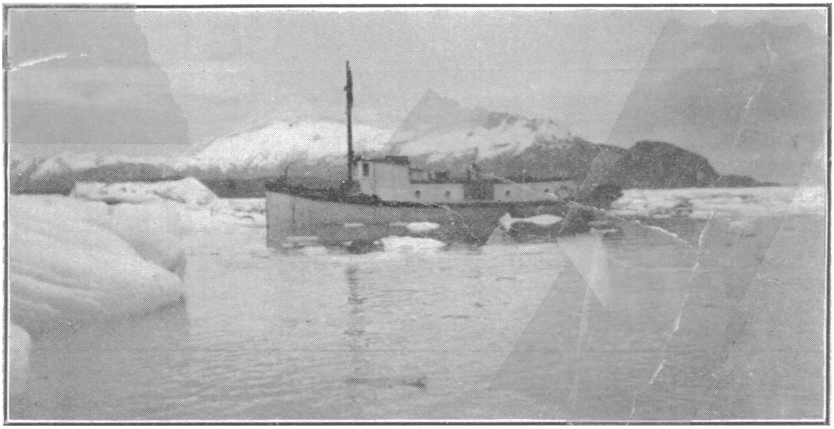

FIG. 14—Our launch anchored to an iceberg off the Columbia Glacier.

MEARES GLACIER

The Meares Glacier is situated at the head of the fiord-like northern part of Unakwik Inlet (Figs. 1, 15, and 16). We named it after Captain John Meares, one of the early explorers of Prince William Sound (1786). We know of no other information than that here noted concerning this glacier, except that Fidalgo in 1790 and probably also Vancouver in 1794 visited Unakwik Inlet and reported that the upper end was blocked by ice. They noted the noise of the falling ice, and we also observed that even to-day the boom of the ice breaking from the front reverberates impressively between the steep mountain walls of the bay.

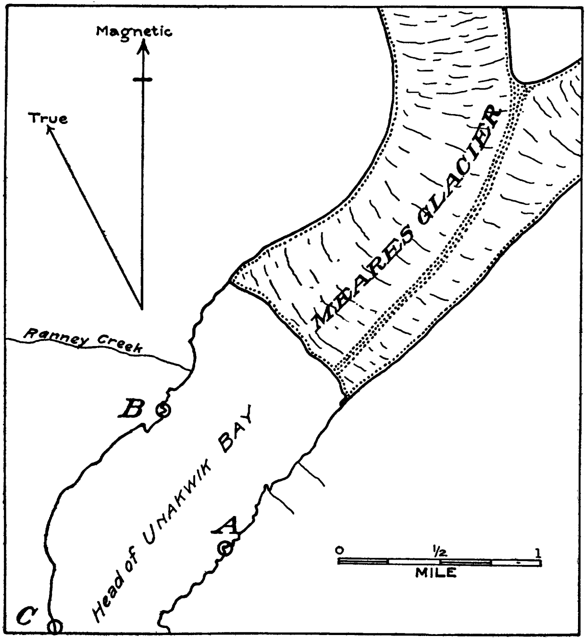

FIG. 15—Sketch map of front of Meares Glacier and vicinity, June 1909. The points marked by circles are stations from which photographs were taken.

In Aug., 1905, a hurried visit to the glacier was made, but the exhaustion of the supply of films prevented the securing of photographic records. On June 26th, 1909, we went up to the head of the bay and mapped and photographed the front. Fig. 16 is the view from station C of Fig. 15. The front of the glacier is four-fifths of a mile wide and at least 300 feet high. The waves caused by huge falling fragments of ice made it unsafe for us to approach closer to the ice than three-quarters of a mile in our dory.

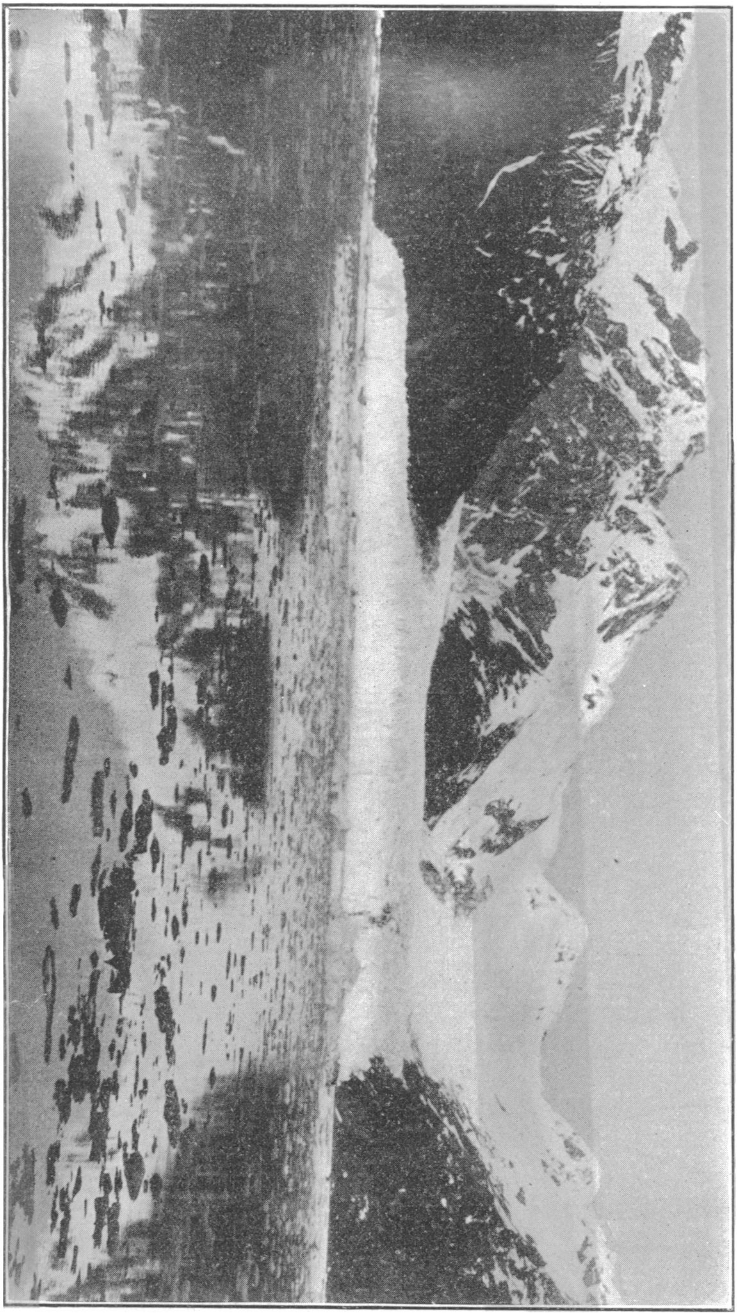

FIG. 16—Front of the Meares Glacier, June, 1909. Photographed from Point C, Fi

In 1905 the bushes and trees were close to the ice and there was no bare zone, or at most a very narrow one, visible between the ice and the forest. In 1909 the front of the ice seemed to be a little in advance of its position of four years before. At the later date near the front of the glacier on the south side was a brown zone estimated to be 200 feet in width. This brown zone appeared to have been caused by dead vegetation rather than by bare rock, and at the edge of the ice there were a few small trees. Close to the glacier there was a sparse forest which contained trees estimated to be ten inches in diameter. Hence the ice was probably as far forward in 1909 as it has been during the last hundred years or more.

Two glaciers join about two miles back from the front to form the main body of the Meares Glacier, and a small medial moraine extends seaward from the point of junction. The ice stream from the north is the larger of the two small streams, and it probably comes from a snow-field which discharges northward also into the Yale Glacier of Port Wells. The front of the Meares glacier is a clear white wall of ice with delicate blue shadows, and although it is not as large as several other glaciers of Prince William Sound, it is, nevertheless, one of the most beautiful.

LOCATION OF THE TOWNS AND CITIES OF CENTRAL NEW YORK

BY

RALPH S. TARR

LARGER GEOGRAPHIC FEATURES. The largest geographic province in the State of New York is a hilly plateau (Fig. 1), the northern portion of the Appalachian plateau which skirts the western base of the Appalachian mountains. This plateau extends northeastward to the Hudson River, where it is known as the Catskill mountains; thence it stretches westward to the western boundary of the State and southward into Pennsylvania. To the north of the plateau, in eastern New York, rise the Adirondack mountains, with the valley of the Mohawk River forming a broad depression between the Adirondacks on the north and the plateau on the south. In central and western New York the plateau is terminated on the north by a more or less perfectly developed escarpment, beyond which, to the north, lies a plain of very level character which extends to the shores